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Project 830016

M.A. Pritchard*, K.W. Savigny*, S.G. Evans**

*Dept. of Geological Sciences, U.B.C, 6339 Stores Rd., Vancouver, B.C. **Terrain Sciences Division, Geological Survey of Canada, 601 Booth St., Ottawa, Ont.

ABSTRACT

Large, deep seated landslides are found in the Beaver River Valley, British Columbia. The Beaver River Valley forms the eastern approach to Rogers Pass, a major transportation corridor through the Columbia Mountains utilized by the Trans-Canada Highway and CP Rail. This report summarizes the geology of the Beaver Valley and outlines the extent and characteristics of deep-seated slope movements affecting the slopes. Previous studies of these mass movements are reviewed and a description and preliminary analysis of field work carried out during the summer of 1988 are given. Research is ongoing into the mechanism of slope failure. Preliminary results suggest that the mass movements represent combined block/flexural and flexural toppling which limits to a planar or curvilinear deep-seated failure.

INTRODUCTION

The Beaver River valley is situated between Golden and Revelstoke, British Columbia (Fig. 1). It forms the eastern part of a narrow transportation corridor which traverses the rugged Purcell and Selkirk Mountains. The route was first discovered and utilized by the Canadian Pacific Railway (now CP Rail) in the late 19th century. The Trans Canada Highway was constructed along the corridor in the early 1960's and a second CP Rail line is scheduled for completion in 1988. Both C.P. Rail alignments enter the northern end of the Beaver Valley along the valley bottom and climb the western slopes. The highway also enters from the north, but high on the eastern slope. It then descends to the valley floor, crosses the Beaver River, and climbs again along the western slope (Fig. 1).

Although the economic importance of the Beaver River Valley as the eastern approach to the Rogers Pass route has long been recognized, the nature and severity of large, deep-seated mass movements along the valley slopes have not yet been documented. This report provides a brief overview of the regional and structural geology of the area, and outlines the characteristics and extent of mass movements. Research into the mode of failure is ongoing on a portion of the valley slopes which was examined in detail during the summer of 1988.

REGIONAL GEOLOGY

The Beaver Valley is situated in the Omineca Tectonic Belt of British Columbia. The northwest trending valley is flanked on the east by the Prairie Hills of the Purcell Mountains and on the west by the Hermit and Sir Donald Ranges of the Selkirk Mountains.

The regional geology is shown in Figure 1. The valley is formed in rocks of two groups: the Hadrynian (Late Precambrian) Horsethief Creek Group, and the Lower Cambrian Hamill Group (Wheeler, 1963; Simony and Wind, 1970). The Horsethief Creek Group includes a lower grit division successively overlain by a slate division, a carbonate division, and an upper clastic division. The slate division is further divided into a semipelite amphibolite unit in the Beaver Valley. The Hamill Group consists of Upper, Middle and Lower Members of which only the dominantly quartzite Lower Member is present in the Beaver Valley (Simony and Wind, 1970).

The east slope of the Beaver Valley consists of a series of imbricate thrust sheets, with the lower slopes formed in the grit and slate divisions of the Horsethief Creek Group and the steeper upper slopes formed in the carbonate division and Lower Hamill rocks. Across the valley only one west-dipping thrust fault interrupts the upright stratigraphic sequence of grit through upper clastic divisions, overlain by Lower Hamill quartzites (Poulton and Simony, 1980).

In the Beaver Valley the rocks are phyllitic to schistose in texture, and are complexly folded exhibiting planar bedding (S0) on the scale of outcrop. Penetrative foliation (S1) that is axial planar to the first phase of folding is virtually obliterated on both sides of the Beaver River by intense crenulation cleavage (S2) (Rickard, 1961; Simony and Wind, 1970). The S0 bedding trends dominantly

northwestward throughout the area, dipping steeply east on the east side of the valley and steeply west on the opposite side (Simony and Wind, 1970). On the east side of the valley the S2 cleavage strikes northwest to northeast and dips more steeply than the S0 bedding.

The large landslides shown in Figure 2 occur in the grit and slate divisions of the Horsethief Creek Group. The lower grit division consists mainly of coarse and fine-grained gritty, feldspathic and micaceous sandstone with slate interbeds (Simony and Wind, 1970); planar bedding and graded beds on the scale of outcrop are common (Poulton and Simony, 1980). The slate division consists of pelitic rocks, with minor coarser clastic and carbonate interbeds transitional with adjacent units.

SLOPE MOVEMENTS IN BEAVER VALLEY

Figure 2 shows the extent of deep-seated slope movements in the Beaver Valley. All of the movements are located on the lower valley slopes and are seated in the Horsethief Creek Group rocks. The exact age of the failures is unknown. However, it is believed that the initial Griffith slide (Fig. 2) predates the last glaciation (Thurber Consultants 1979), and that all show evidence of post glacial movement.

Natural slope angles in the valley vary from 23 to 40 degrees. The height of the landslides, measured from the valley floor (approximately 825 meters a.s.l.) to the top of the headscarps, varies from 450 to 1250 meters. The volume of the slope movements varies from approximately 5 to 30 $x10^6 m^3$.

Progressive deformations have been measured at the Griffith slide (Fig. 2) where continuous movement of the debris has caused displacement of the current CP Rail line throughout its life, necessitating detailed geotechnical studies and stabilization works. Monitoring of slope indicators shows deformations of up to approximately 30 mm over a one month monitoring period (Thurber Consultants Ltd., 1979). Whether or not other deep seated mass movements are moving, and their rate of movement are not yet known.

Previous unpublished work describes and quantifies the mode of failure of the slopes. In a report to CP Rail, EBA Engineering Consultants Limited (1976) outlined the location of many slope

movements in the valley. Based on the geometry of the bedrock slide scarps and rubble EBA suggested that the mode of failures is circular. In a later report (1978) for Environment Canada Parks, EBA evaluated the stability of the Heather Hill landslide as a deep-seated rotational failure (circular). Piteau and Associates (1982), in work for C.P. Rail on the west valley slope near the entrance to Rogers Pass, observed several localities where preexisting toppling failures (Goodman and Bray, 1976) are exposed by railway or creek cuts. Rapp (1987), using the nomograms developed by Brown (1982), confirmed that large scale toppling failure is possible in the valley slopes; furthermore, Rapp postulated that slides such as the Griffith and Unnamed slide represent the final stages of earlier massive toppling failures.

HEATHER HILL LANDSLIDE AND ADJACENT SLOPES

Ongoing research at the University of British Columbia centers on resolving the mode of failure of the slopes of the Beaver River Valley. Field work during the summer of 1988 concentrated on an area of the east slope of the Beaver River Valley including the Heather Hill landslide and adjacent slopes to the north (Fig. 1). This site was selected for detailed study because it contains a well developed and well defined, deep-seated landslide, and the opportunity to study slopes immediately adjacent which show lesser degrees of deformation.

The geology of the site consists of the lower grit and slate divisions of the Horsethief Creek Group. Preliminary analysis of the field data indicates several dominant structural features: S0 planar bedding foliation, S2 crenulation cleavage, and at least two joint sets (J1, J2). S1 axial planar foliation exists, and appears to be subparallel to the S0 bedding foliation. However, the orientation of this foliation is difficult to quantify due to the effect of S2 crenulation cleavage. The J1 joint set trends northwesterly, parallel to the strike of the beds and dips downslope perpendicular to the S0 bedding foliation. The J2 joint set is oriented perpendicular to both the S0 bedding foliation and the J1 joint set. These joint sets occur most commonly in the more competent gritty beds, separating these beds into large blocky fragments.

Evidence of slope movement was discovered during field work. Downslope overturning of bedding is visible where high, near vertical cuts (60m) are exposed in creek valleys. In these creek cuts overturning and dilation are seen clearly to increase updip. Possible evidence of recent movement was found immediately north of the Heather Hill landslide and upslope of a cut backslope along Highway 1 where no deep-seated mass movement was suspected. This evidence consists of obsequent scarps with torn surficial soil and roots and relief of up to 1.5 meters.

Based on this preliminary work, it is believed that combined deep-seated flexural and block/flexural toppling failure (Goodman and Bray, 1976) with shear along S0 bedding foliations and/or S2 cleavage initially causes the rock mass to dilate. Increasing displacement and overturning leads to the break up of more competent beds along orthogonal joints, further loading the weaker pelitic (slate) beds which ultimately results in deep-seated failure. The failure surface may be planar or have a composite curvilinear shape. A curvilinear shaped failure surface, similar to the Heather Hill slide, may be due to stepping of the failure surface along discontinuities in the gritty beds and along shear or fracture surfaces in the pelitic beds.

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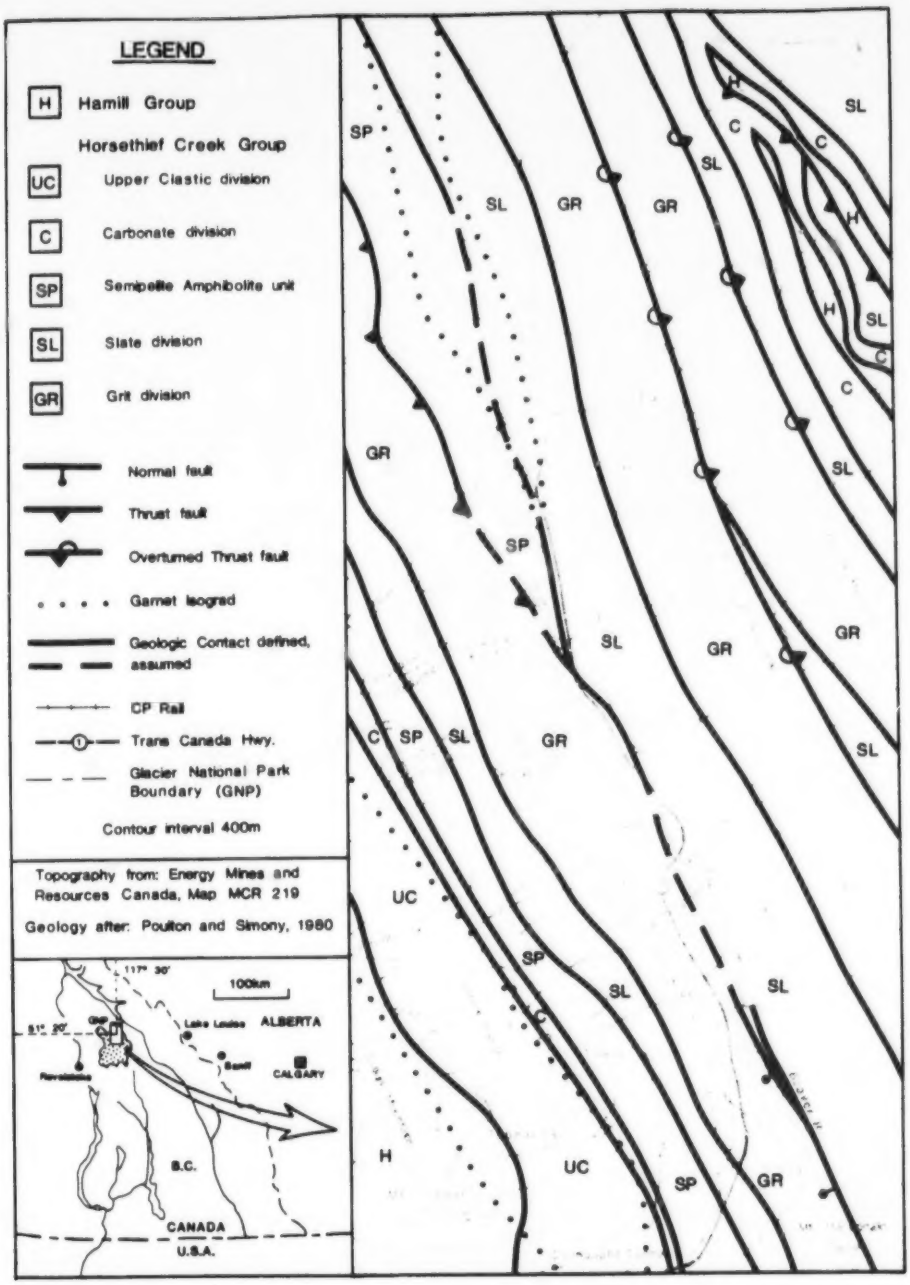

Figure 1: Location map and Regional Geology map of the Beaver Valley (After Poulton and Simony, 1980)

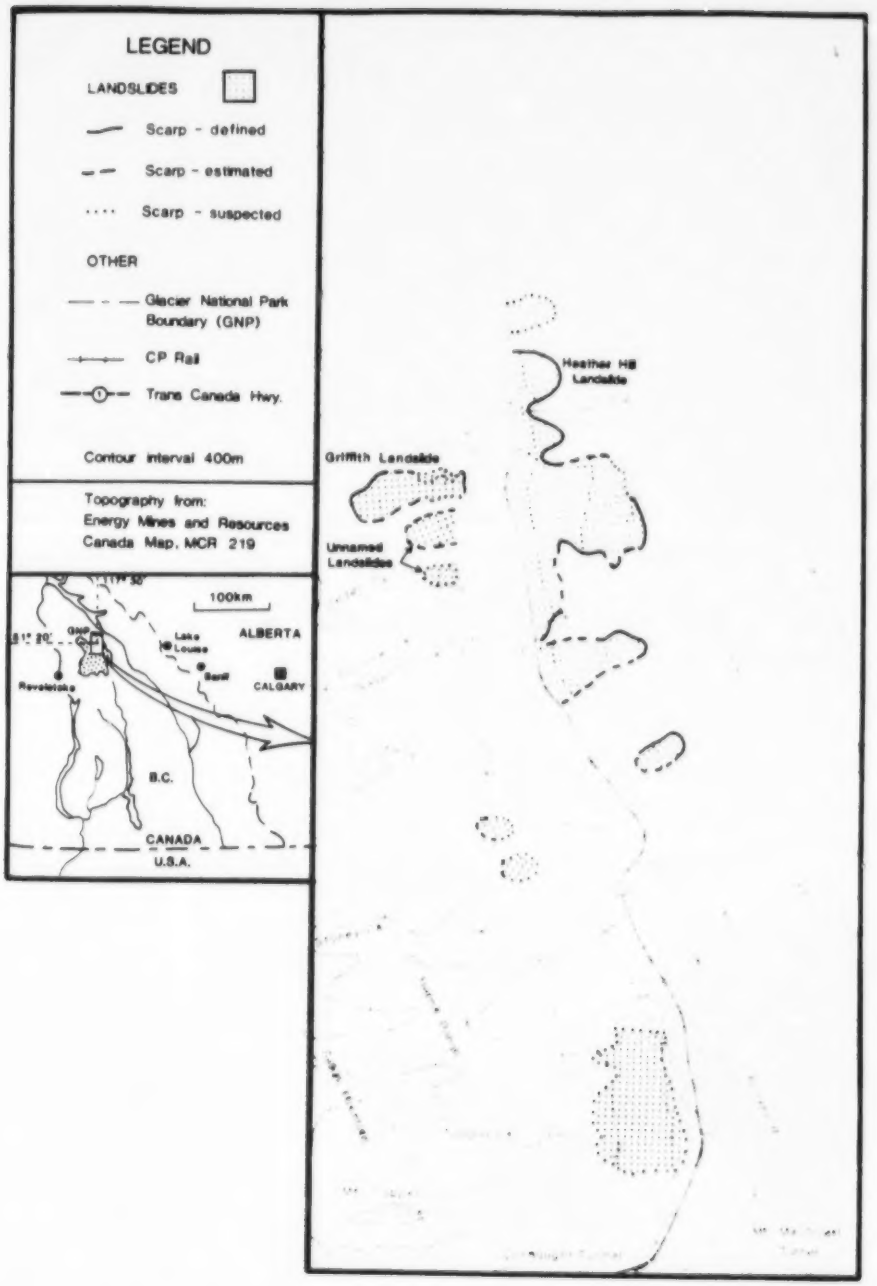

Figure 2: Topographic map of the Beaver Valley showing location of deep-seated landslides.